ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Geological report at the seismic station IV.FERS – Casaglia (FE)

Report geologico per il sito della stazione sismica IV.FERS – Casaglia (FE)

Working Group: **Luca MINARELLI**	Date: Dicembre 2019
Subject: **Final report illustrating the geological setting for station IV.FERS**	

Convenzione DPC-INGV 2019-21, All.B2- WP1, Task 2: "Caratterizzazione siti accelerometrici" (Coord.: G.Cultrera, F. Pacor)
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1. INTRODUCTION

The geological description is related to the site of studied seismic station. The coordinates are reported in Table 1.

Table 1.

CODE	NAME	LAT [°]	LON [°]	ELEVATION [m]
IV.FERS	Casaglia (Ferrara)	**44.903588** 44.90350*	**11.540541** 11.54060*	7
ADDRESS	Via del Riposo, 36, 44123 Ferrara FE, Italy			

* Coordinates from ITACA (Dec. 2019)

2. TOPOGRAPHIC AND GEOLOGICAL INFORMATION

Topographic information related to the site are reported in Table 2. Table 3 summarizes all available geological maps from literature for geological analyses.

Table 2.

Topography	Description	Topography Class	Morphology Class	EC8 Class
	Flat surfaces, isolated slope and reliefs with slope i<=15°	T1	P (Plain)	C

Table 3.

Geological map	Source	Scale
IV.FERS	Geological map of Italy sheet *N.76* (Ferrara)	1:100.000
IV.FERS	Geological and technical map – Seismic Microzonation	1:10.000

In Table 4 Geological, Lithological and Lithotechnical Units (according to Seismic Microzonation classification; Technical Commission MS, 2015) are described and are concerned to maps of following chapters. The term "original" means the result comes from a preexisting cartography (Table 3); the term "deduced" means the result comes from an interpretation of a preexisting cartography according to the nomenclature of corresponding cartography.

Table 4

GEOLOGICAL UNITS		**LITHOLOGICAL UNITS**		**LITHOTECHNICAL UNIT**	
deduced. According to the nomenclature of geological map of Italy 1:50.000 (Sheet 204 –Poggio Renatico)		*(ISPRA) original*		(MZS) *original*	
code	**description**	**code**	**description**	**code**	**description**
AES8	Clay and silty clay	B3	Gravelly sandy soils	OLpi	Organic silts or low-plasticity organic silty clays of interfluvial plain
AES8	Silt and sandy silt			MLes	Inorganic silt, silty fine sands or clay, clay silt of low plasticity

3. GEOLOGICAL MAP

In Figure 1 Geological Map is reported in a 1kmx1Km square around the station.

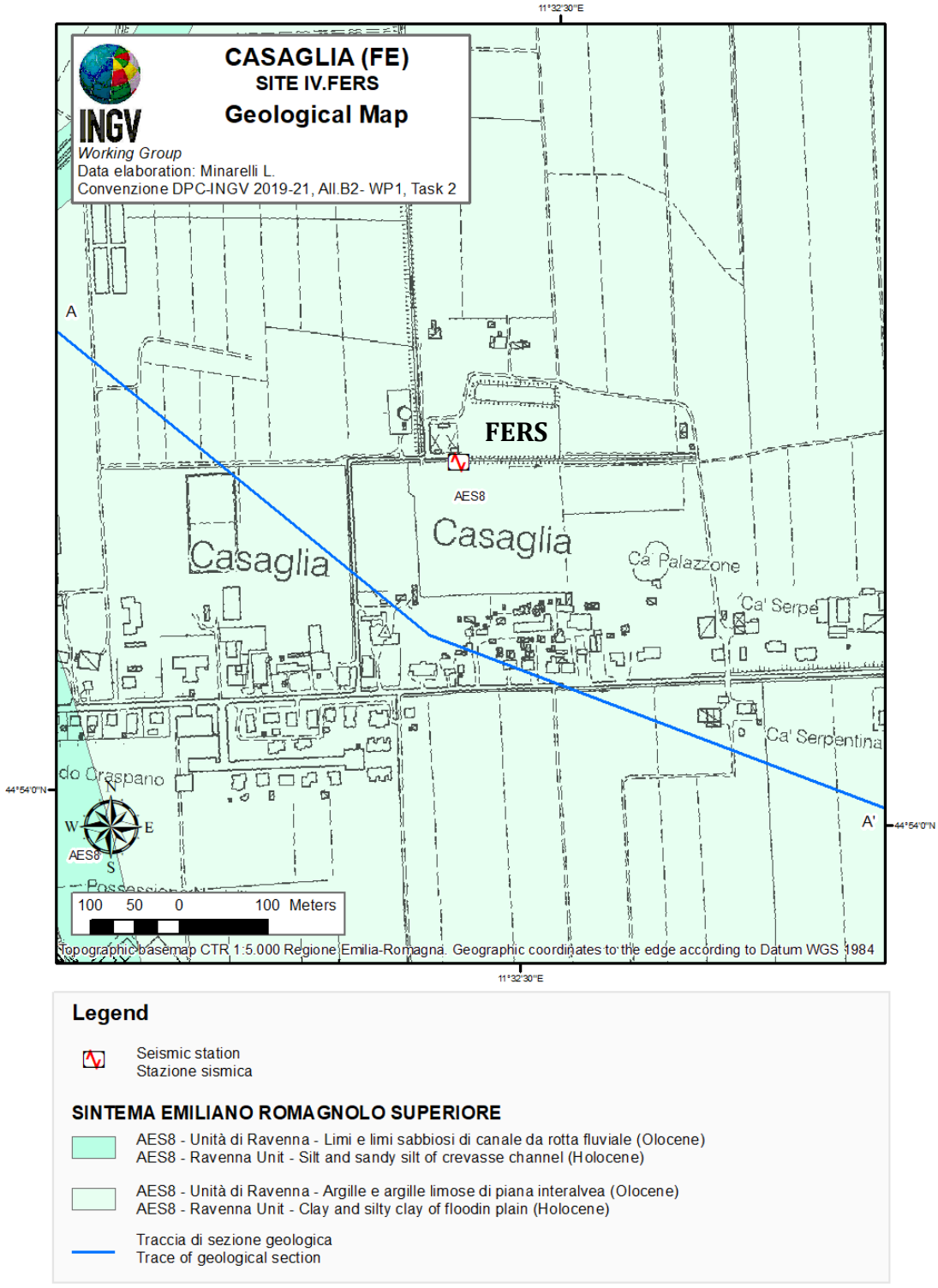

Figure 1. Geological map of seismic station IV.FERS. Scale 1:5.000. Geological units are established according to the nomenclature of geological map of Italy 1:50.000 (Sheet 204 –Poggio Renatico).

4. LITHOTECHNICAL MAP

In Figure 2 Lithotechnical Map is reported in a 1kmx1Km square around the station.

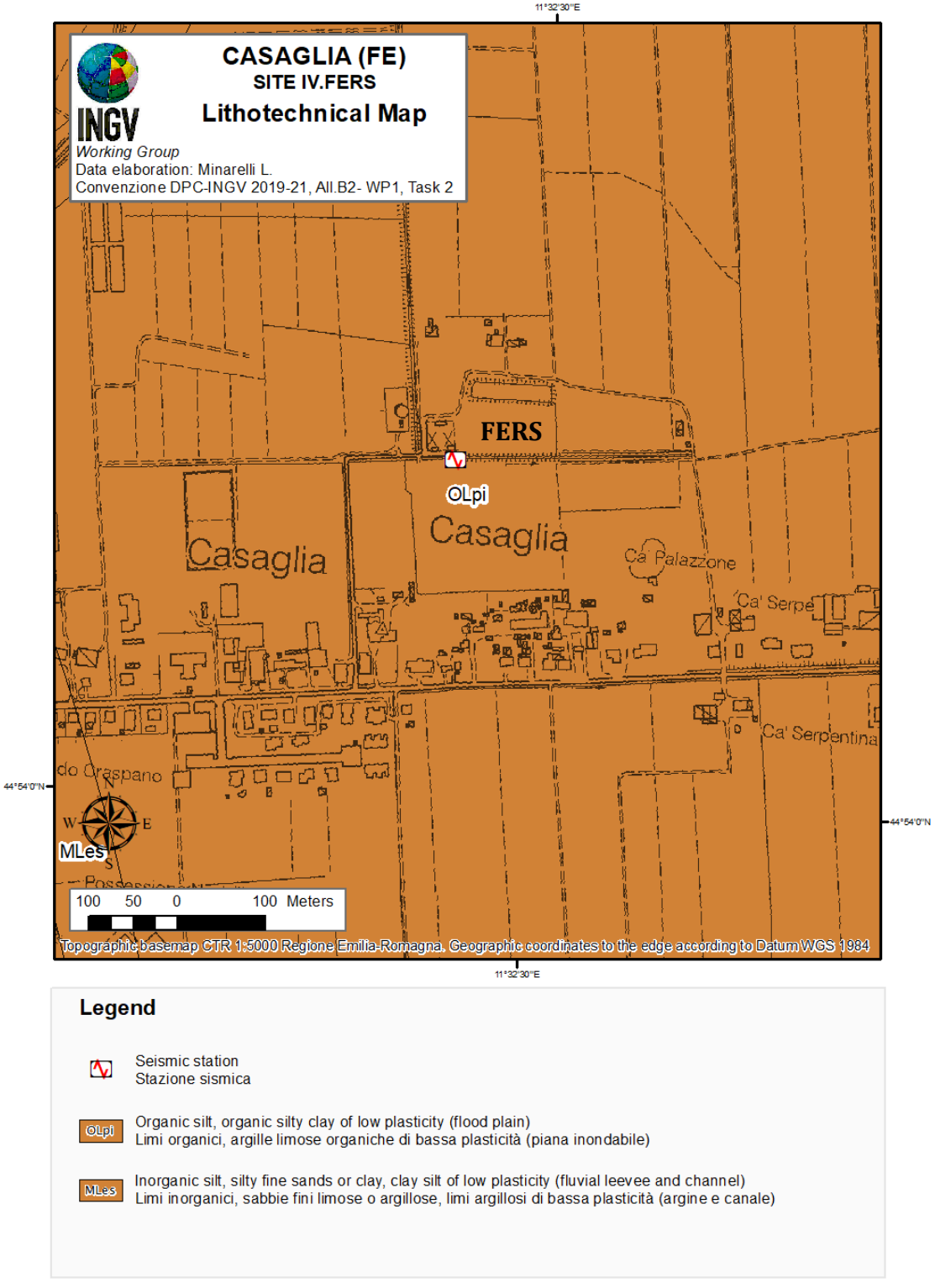

Figure 2: Lithotechnical map of the seismic station IV.FERS. Scale 1:5.000. The lithotechnical units are assigned according to the nomenclature of Seismic Microzonation (Technical Commission MS, 2015).

5. SURVEY MAP

Figure 4 shows the survey Map reported previous geotechnical and geophysical investigations used for the characterization of the area.

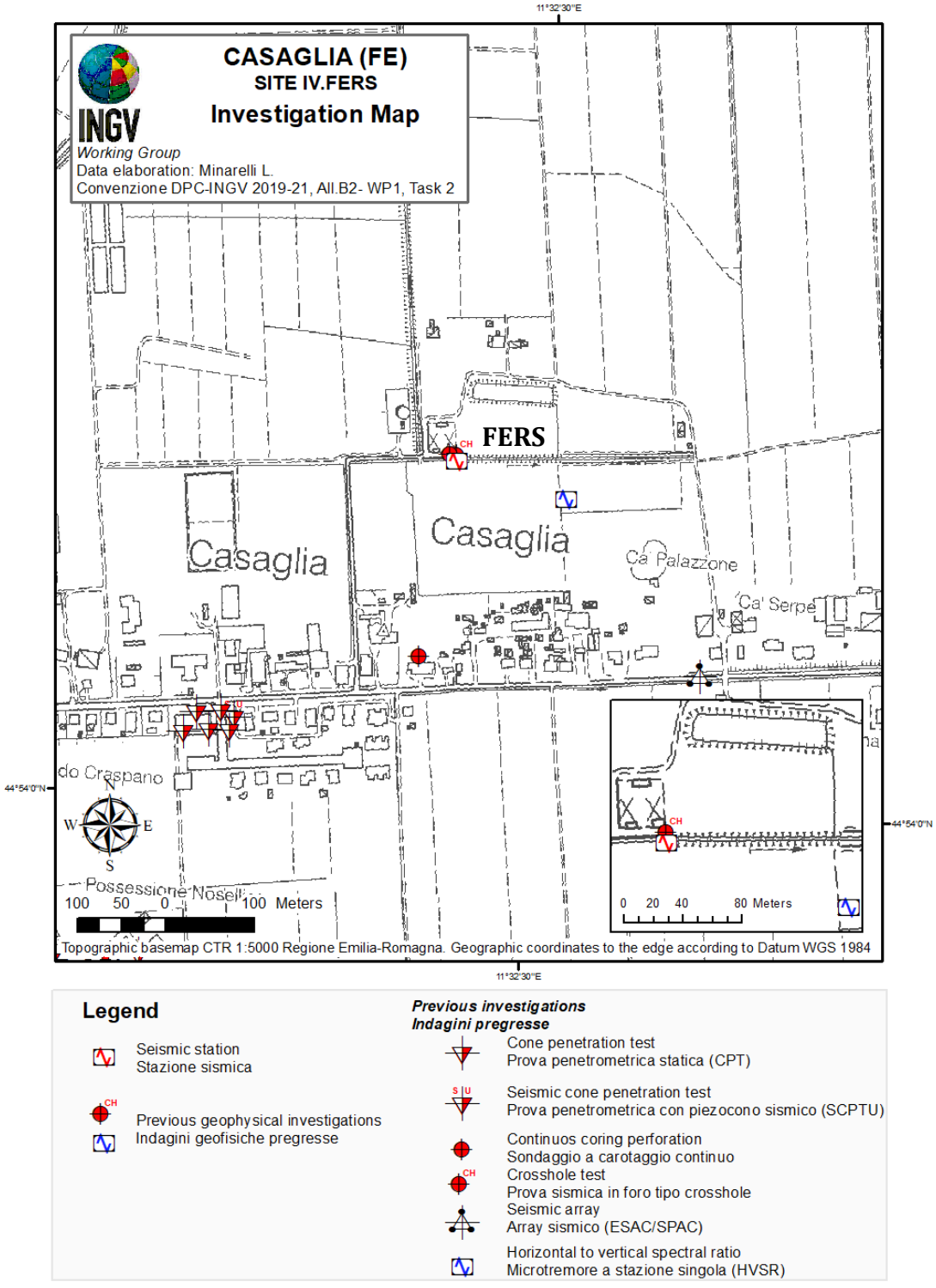

Figure 3: Map of the surveys in the surroundings of the station IV.FERS. Scala 1: 5.000. The box at the bottom right contains a zoom of the area with the detail of the cross-hole geophysical investigation used for the seismic characterization of the site (http://itaca.mi.ingv.it/ - Laurenzano et. al. 2013).

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6. GEOLOGICAL MODEL

6.1 General description

The Casaglia Seismic station is placed in the lower alluvial plain of the River Po, at 7 m of topographic elevation, near the northwestern outskirt of Ferrara.

The site corresponds to the culmination area of a ramp anticline related to the frontal thrust of the buried Apennines Chain (Pieri & Groppi 1981) (Figure 4). The structure developed during Quaternary times and is associated with an individual seismogenic sources ITIS090 (DISS Working Group, 2018). The complex anticline structure is detached from the metamorphic basement and involves Mesozoic carbonates and Tertiary deep-water marls and lithified claystones (Figure 4 and Figure 5).

The carbonate rocks forming the anticline nucleus host an exploited geothermal fields. The Quaternary uplift of the structure induced sharp stratigraphic discordances. The Miocene is therefore cut by an erosive surface, associated with a strong acoustic impedance contrast, marking the top of the seismic basement, here reaching 130 m, a much shallower depth than in the surrounding areas. A portion of the Miocene, the entire Pliocene and the lower Pleistocene are here missing (Carta Geologica d'Italia scala 1:100.000 - Foglio 76 - Ferrara - Vincenza Nuova core). In the surrounding areas, the stratigraphic discordance surface is deeper in position and gradually fades away, grading into the much thicker and continuous Tertiary and Quaternary marine successions of the adjacent synclines.

At the station site, the middle and upper Quaternary consists of unlithified terrigenous sediments, belonging to two stratigraphic units. Between about 130 and 100 m, coastal and deltaic sands and silts, with shallow marine fossils, are present. The sediments are mainly framed within the Sintema Emiliano-Romagnolo Inferiore (AEI); the presence of the Marine Quaternary Unit in the lowermost part of the interval is poorly documented, but cannot be ruled out.

The upper portion of the subsurface entirely consists of alluvial plain deposits (see following description). The alternation of synglacial coarse sand and inter-glacial finer grained levels, richer in organic matter, peat and wood remains, records large climatic and eustatic fluctuations.

According to the CARG stratigraphic terminology, these continental deposits are framed into

the Sintema Emiliano-Romagnolo Superiore (AES), accumulated through about the last 600,000 yr. The Synthem is subdivided into several Subsynthems, the younger ones being AES6, AES7, and AES8.

The synglacial sands forming the upper portion of AES7 (Subsintema di Villa Verucchio). The shallower portion of the subsurface consists here of Holocene clay and silty clay with some fine sand intercalation and is framed within the Subsintema di Ravenna (AES8).

The unit is here dominated by fine grained, cohesive muds, deposited into an interfluvial area, since no river channel passed through the discussed site during the Holocene Epoch.

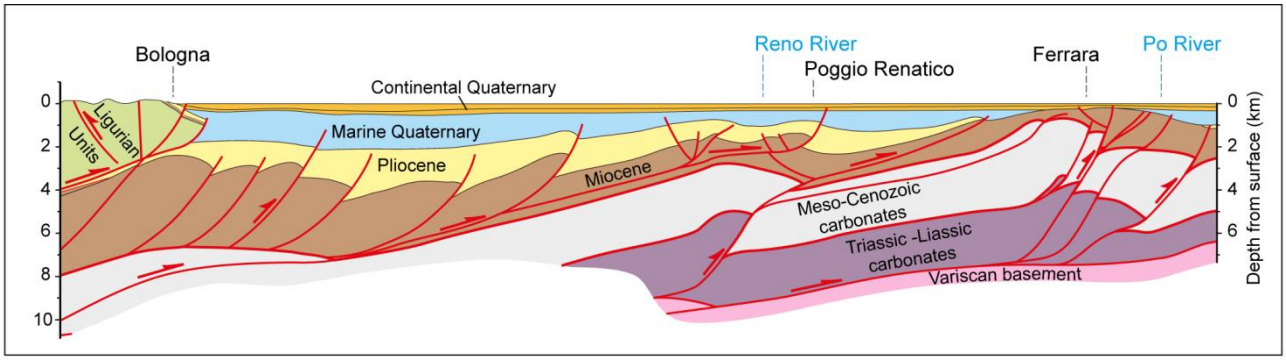

Figure 4: Structural profile, modified from Boccaletti et al. (2004). The Meso-Cenozoic cover is detached from the metamorphic basement and involved into active compressive deformation. Two complex anticline structures are associated with ramp overthrusts, interspaced by two large synclines.

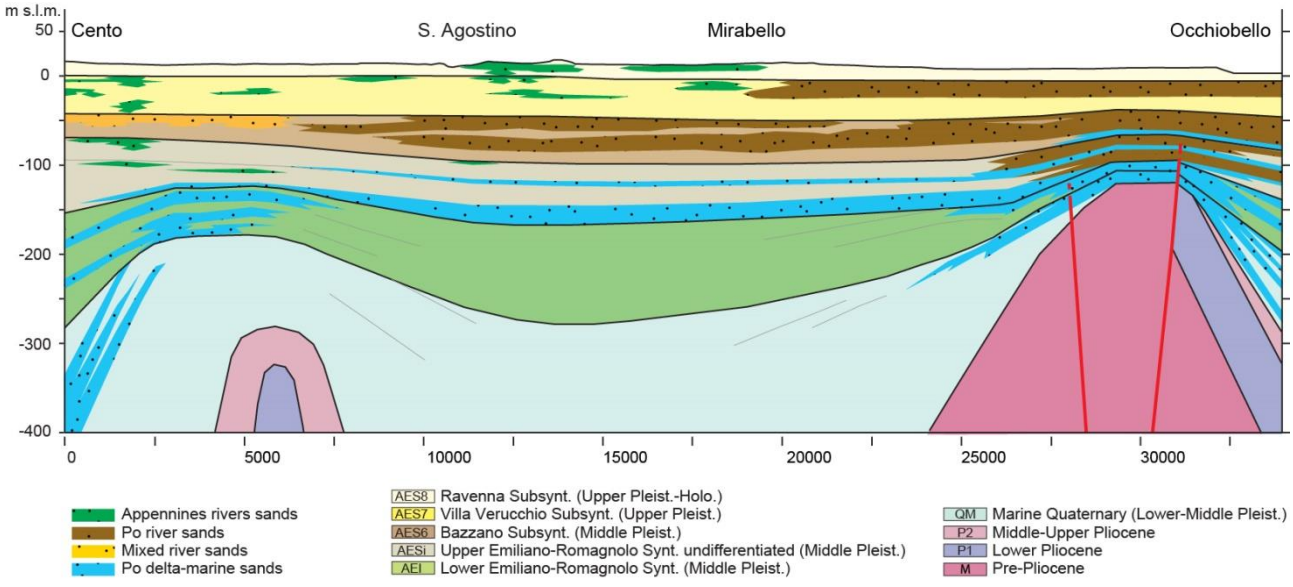

Figure 5: Geological cross section interpreting the first 400 m of subsurface between Cento and Occhiobello. The impact of the active tectonic deformation and the associated differential sediment compaction on the stratigraphic geometry is clearly visible. Modified from Martelli et al. (2017).

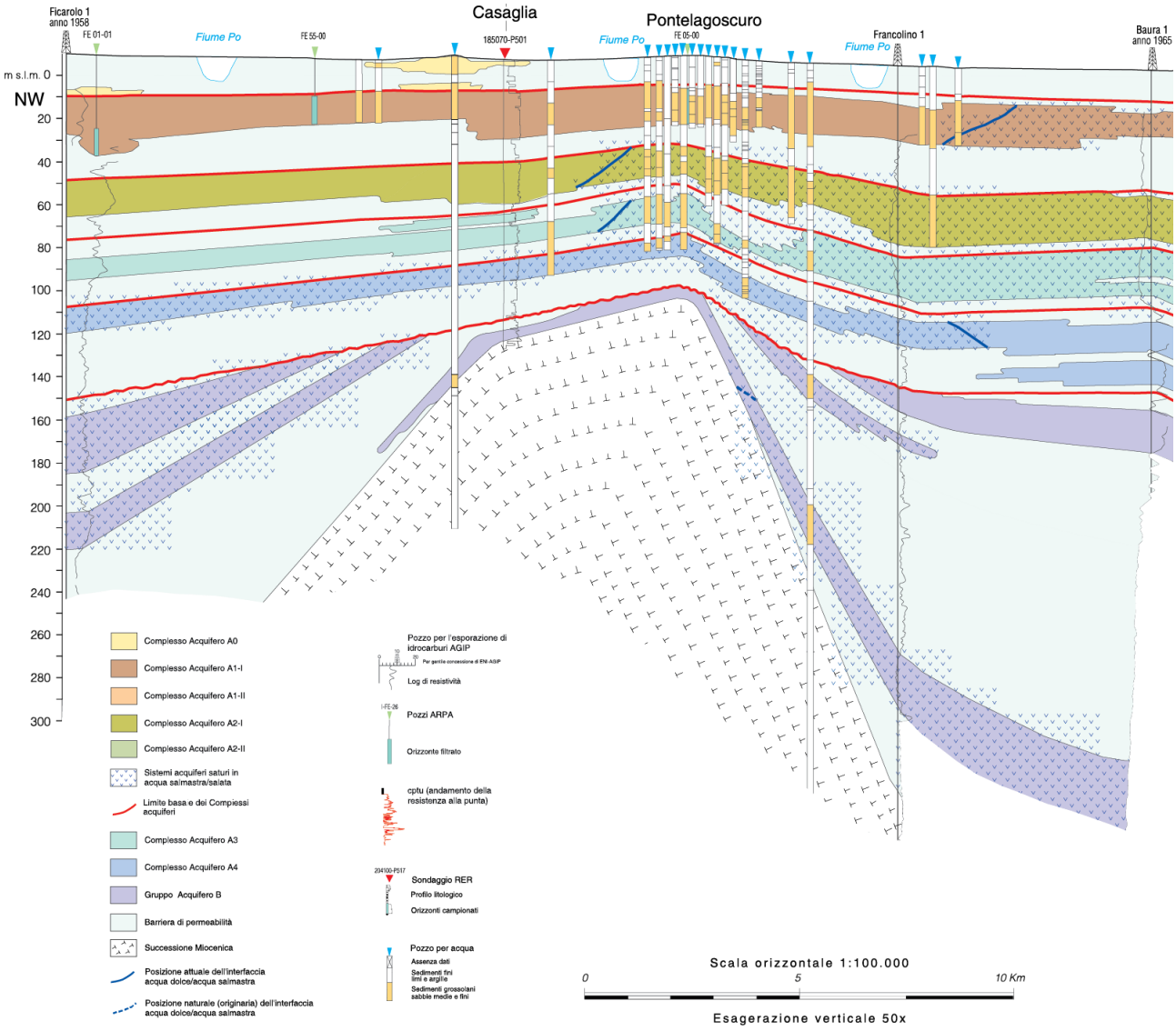

Figure 6: Hydrogeological section that crosses the study area. Modified from Molinari et al. (2007).

6.2 Geological Section

A detailed knowledge of the station site subsurface is available, thanks to a stratigraphic core and several stratigraphic profiles. A continuously cored stratigraphic well was drilled just 200 m (185070-P501; Figure 7), within the framework of the geological research performed by the Servizio Geologico, Sismico e dei Suoli della Regione Emilia-Romagna.

A synthetic description of it is hereafter provided and compared to adjacent successions.

The first 15 m of subsurface belongs to the **Subsintema di Ravenna** (AES8). In adjacent areas, the subsynthem comprises important, elongated sand bodies, deposited into Po River channels. The shallower portion (0-9 m) consists of clay and silty clay, sedimented into a moist interfluvial depression. Silt, sandy or argillaceous silts, with palaeosol levels (9-15 m) deposited into an alluvial plain setting, follow.

The following interval (15-46.5) belongs to the **Subsintema di Villa Verucchio** (AES7). Its upper portion (15-36.5 m) is formed by middle to coarse-grained fluvial sands, poor in wood remain, sometimes with pebbly deposited during synglacial times. The sand body is laterally rather continuous. At the regional scale, the sandy unit forms the aquiferous body A1.1, visible in the profile (Figure 6 and Figure 7). The lower portion of the subsynthem (36.5-46.5 m) is finer grained in nature, consisting of lay, sitly clay and silt, sometimes sand, with organic rich levels and pelecypod remains. In the lowermost part, paleosols with carbonate concrections are present. The lower portion was deposited into an inter-glacial alluvial plain.

The **Subsintema di Bazzano** (AES 6) follows (46.5-76.5 m). The upper interval (46.5-58.5 m) is formed by middle-coarse sand, with some pebbly sand layers, deposited into a synglacial alluvial plain. Sand, from fine to coarse in nature, with wood and root remain, were then found (58.5-65 m).

The interval (46.5-76.5) corresponds to the aquiferous A.2.1, depicted in green in the profile. The following interval (65-76.5 m) is again formed by clay and silt, with levels enriched in organic matter, sedimented into and interglacial lower alluvial plain.

The **lower portion of AES** (76.5-101-5) is again formed by alternating coarser and finer grained units. Middle to coarse sand (76.5-84.5 m), with some pebbles, forms the aquiferous unit A.3.

Fine grained, silty sand and silt, sometimes argillaceous, with wood remains and mollusk bioclasts, form the following interval (84.5-90 m) , deposited into a intergalacial lower alluvial plain. Middle to coarse grained sand and gravel made the following interval (90-101.5 m) accumulated into a fluvial environment and corresponding to the aquiferous A4.

The lower interval (10.5-130.5 m) belongs to the Sintema Emiliano-Romagnolo Inferiore (AEI) and, perhaps, to the Quaternario Marino Unit. The interval is formed by sands,

sometimes silty sand, with bioclastic and graded beds, probably storm layers, record deltaic and coastal marine environments.

At 130.5 m, a **major discordance surface**, angular in nature, marks the eroded top of a **Miocene formation** (Figure 7).

6.3 Subsoil model

A subsoil model is built up a depth of 200 m for the area around the IV. FERS station (Figure 7) based on geological information, hydrocarbon drilling and public database. According to Seismic Microzonation of the Ferrara Municipality (Università di Ferrara, 2014) and its subsequent integrations (Geotema, 2020), the seismic bedrock has been placed on the top of the marly Miocene deposits, in correspondence of a sharpest seismic impedance contrast, characterized by Vs around 900 m/s.

The stratigraphic profile and geological model proposed in this report are in accord with the cross-hole velocity profile used for the seismic characterization of the site (Laurenzano et. al. 2013) available in the monography presents in the Italian Accelerometric Archive "ITACA" (Luzi et. al. 2019 – http://itaca.mi.ingv.it/ItacaNet_30/#/station/IV/FERS).

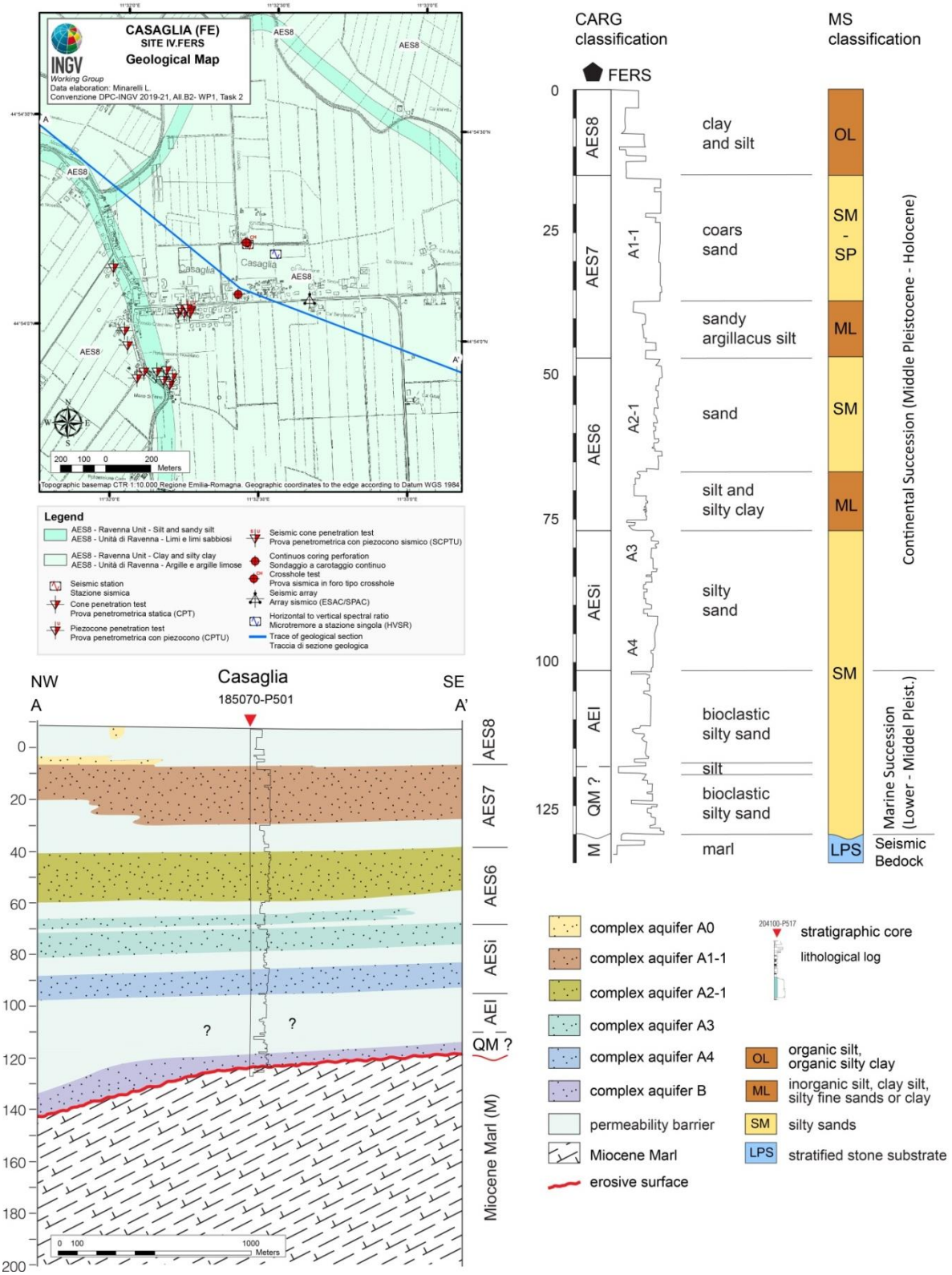

Figure 6: Bottom left: Geological section A-A' crossing seismic station IV.FERS. Right: Subsoil model under the IV.FERS seismic station and classification according nomenclature of geological map of Italy 1:50.000 and according to Seismic Microzonation (MS).

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